CN

EQUIPMENT DEPARTMENT
MOTIVE POWER

TP 6808 E

DOPPLER RADAR LOCOMOTIVE SPEEDOMETERS (RADOMETERS) CMI INC. FIELD EVALUATION

PREPARED FOR THE

TRANSPORTATION DEVELOPMENT CENTRE

TRANSPORT CANADA

CN - OPERATIONS
DE LA GAUCHETIERE ST. WEST
NTREAL, QUEBEC
2M9

CA1
DTC 845
85
D56
c.2

TEMBER 1985

Library and Information Centre
Centre de Documentation (GSL)
RECEIVED - REÇU LE
DEC 5 1985
Transport Canada

TP 6808E

DOPPLER RADAR LOCOMOTIVE SPEEDOMETERS (RADOMETERS) CMI INC.

FIELD EVALUATION

BY

K. H. Kilpatrick - System Electrical Officer - Motive Power
R. J. Lusk - System Mechanical Officer - Motive Power
R. Lauzon - Technical Officer, Electrical - Motive Power

CN Rail Operations
935 de la Gauchetiere St. West,
Montreal, Que.
H3B 2M9

September 1985

03PERM/RL16nk

The contents of this report reflect the views of the contractors and not necessarily the official views of policies of the Transport Canada, Transportation Development Centre.

REPORT DOCUMENTATION FORM

1. Transport Canada Report No.	2. TDC Project No.	3. Recipient's Catalogue No.
TP 6808E	4530	

4. Title and Subtitle	5. Report Date
DOPPLER RADAR LOCOMOTIVE SPEEDOMETERS (RADOMETERS) - CMI INC. FIELD EVALUATION	June 1985
	6. Performing Organization Report No.

7. Author(s)	8. Transport Canada File No.
K.H. Kilpatrick, R.J. Lusk, R. Lauzon	D1465-285-9

9. Performing Organization Name and Address	10. DSS File No.
CN Rail - Operations 935 de La Gauchetière Street West Montreal, Quebec H3B 2M9	09SD.T8200-1-1562
	11. DSS or Transport Canada Contract No.
	OSD81-00163

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Transportation Development Centre (TDC) Guy Favreau Complex 200 Dorchester Blvd. West, Suite 601, West Tower Montreal, Quebec H2Z 1X4	Tech; Nov. 83/June 85
	14. Sponsoring Agency Code
	TDC 4530

15. Supplementary Notes	16. TDC Project Officer
	D.W. Dibble

17. Abstract

This report presents the results of a CN Rail field evaluation of eleven CMI Doppler Radar locomotive speedometers (radometers) which operate independently from locomotive wheels. The radometer is an electronic speedometer specially designed for use on railroad locomotives, requires no calibration to compensate for wheel size and is accurate even during wheel slip conditions. The instrument consists of an antenna/transceiver unit for mounting under the locomotive frame, a processor/readout module (speedometer) for mounting in locomotive cab and an interface cable for connecting these modules. Ten locomotives plus the CN Research & Development test car were equipped with radometers, which were evaluated from September 1983 to May 1985. The majority of problems encountered with the system were related to the display unit: i.e., glare reflection from the plastic lense (window) covering the display, dull visual speed display in daylight caused by the lack of contrast between the display background (grey colour) and the display numerals (black colour) and the occasional erratic speed readout at certain locomotive speeds. It is noted that 90% of the radometer applications experienced one or more road failures, requiring the return of the equipment for repairs.

18. Key Words	19. Distribution Statement
Radometer, Locomotive, Field Trials Tests, Processor/Readout Display Antenna/Transceiver	Limited number of copies available from the Transportation Development Centre

20. Security Classification (of this report)	21. Security Classification (of this page)	22. No. of Pages	23. Price
Unclassified	Unclassified		--

FORMULE DE DOCUMENTATION POUR RAPPORT

1. N° du rapport Transports Canada	2. N° de l'étude — CDT	3. N° de catalogue du destinataire
4. Titre et sous-titre		5. Date du rapport
		6. N° du rapport de l'organisme exécutant
7. Auteur(s)		8. N° de dossier Transports Canada
9. Nom et adresse de l'organisme exécutant		10. N° de dossier — ASC
		11. N° de contrat — ASC ou Transports Canada
12. Nom et adresse de l'organisme parrain		13. Genre de rapport et période visée
		14. Code de l'organisme parrain
15. Remarques additionnelles		16. Agent de projet — CDT

17. Résumé

18. Mots-clés	19. Diffusion		
20. Classification de sécurité (de ce rapport)	21. Classification de sécurité (de cette page)	22. Nombre de pages	23. Prix

CDT TDC 79-005

FORMULE DE DOCUMENTATION POUR RAPPORT

1. Nº du rapport Transports Canada	2. Nº de l'étude — CDT	3. Nº de catalogue du destinataire
TP 6808E	4530	

4. Titre et sous-titre	5. Date du rapport
DOPPLER RADAR LOCOMOTIVE SPEEDOMETERS (RADOMETERS) - CMI INC. FIELD EVALUATION	juin 1985
	6. Nº du rapport de l'organisme exécutant

7. Auteur(s)	8. Nº de dossier Transports Canada
K.H. Kilpatrick, R.J. Lusk, R. Lauzon	D1465-285-9

9. Nom et adresse de l'organisme exécutant	10. Nº de dossier — ASC
CN Rail - Opérations 935 ouest, de la Gauchetière Montréal, Qué H3B 2M9	09SD.T8200-1-1562
	11. Nº de contrat — ASC ou Transports Canada OSD81-00163

12. Nom et adresse de l'organisme parrain	13. Genre de rapport et période visée
Centre de développement des transports (CDT) Complexe Guy Favreau, tour ouest 200 o., boul. Dorchester, suite 601 Montréal, Qué H2Z 1X4	Tech. nov 83/juin 85
	14. Code de l'organisme parrain CDT 4530

15. Remarques additionnelles	16. Agent de projet — CDT
	D.W. Dibble

17. Résumé

Ce rapport rend compte de l'évaluation en service, faite par CN Rail, de onze indicateurs de vitesse à effet Doppler pour locomotives, fabriqués par CMI et dont l'avantage est de ne pas être solidaires des roues. Cet appareil électronique ne requiert donc pas d'étalonnage pour tenir compte du diamètre des roues, ni ne se ressent de l'effet de patinage. Il comporte une antenne émettrice-réceptrice montée sous la locomotive, un module de traitement/lecture (indicateur) placé en cabine et un bus d'interfaçage reliant ces deux unités. Dix locomotives et un véhicule utilisé par le CN pour les besoins de la recherche ont été équipés de ces appareils, dont l'évaluation en service a eu lieu de septembre 1983 à mai 1985. La plupart des points faibles constatés sont reliés à l'unité d'affichage: réverbération de la lumière par la lentille plastique protégeant l'unité, manque de contraste le jour entre la platine d'affichage de couleur grise et les chiffres de couleur noire et, à l'occasion, un affichage erratique à certaines vitesses. Il est à noter que 90% de ces appareils ont connu une défaillance ou plus lors des essais et qu'ils ont dû être renvoyés au fabricant pour réparation.

18. Mots-clés	19. Diffusion
Indicateur de vitesse, locomotive, essais en service, traitement/lecture, antenne émettrice-réceptrice, affichage	Le CDT dispose d'un nombre limité d'exemplaires

20. Classification de sécurité (de ce rapport)	21. Classification de sécurité (de cette page)	22. Nombre de pages	23. Prix
non-classifié	non-classifiée		-

REPORT DOCUMENTATION FORM

1. Transport Canada Report No.	2. TDC Project No.	3. Recipient's Catalogue No.
4. Title and Subtitle		5. Report Date
		6. Performing Organization Report No.
7. Author(s)		8. Transport Canada File No.
9. Performing Organization Name and Address		10. DSS File No.
		11. DSS or Transport Canada Contract No.
12. Sponsoring Agency Name and Address		13. Type of Report and Period Covered
		14. Sponsoring Agency Code
15. Supplementary Notes		16. TDC Project Officer

17. Abstract

18. Key Words	19. Distribution Statement

20. Security Classification (of this report)	21. Security Classification (of this page)	22. No. of Pages	23. Price

TDC CDT 79-005

TABLE OF CONTENTS

	Page No.
1.0 INTRODUCTION	1
1.1 Overall Objective	1
1.2 Project Objective	1
2.0 SYSTEM DESCRIPTION	
2.1 General	1
2.2 System Components	1
2.3 System Operation	1
3.0 SYSTEM INSTALLATION	2
3.1 Antenna/Transceiver	2
3.2 Processor/Readout Display (Speedometer)	2
3.3 Cabling	2
3.4 CMI Model DT-101 Testing Instrument	2
Applications of Radometers to locomotives	3
4.0 WORK PERFORMED	3
4.1 Work Accomplished	3-6
5.0 TEST RESULTS	6
6.0 RECOMMENDATIONS	7

LIST OF FIGURES

		Page No.
Fig. 1	Antenna/Transceiver Location No.1 END Drawbar Pocket	8
Fig. 2	Cabling between Transceiver and display unit in cab - locomotive under frame	8
Fig. 3	Central Cab Mount Display Unit	9
Fig. 4	CMI Model DT-101 Verifier	10

1.0 INTRODUCTION

This is the second phase of a project which originated with the Railway Advisory Committee for the investigation of various locomotive speedometers which operate independently of wheel rotation. The first phase study concluded with the selection of the CMI Radar Speedometer as the most promising candidate to undergo a field evaluation program. As CN Rail has indicated their support in undertaking a joint field evaluation with Transportation Development Center of this speedometer, the project was initiated.

1.1 OVERALL OBJECTIVE

To provide a speedometer which operates independently from locomotive wheels for use on Canadian Railroads.

1.2 PROJECT OBJECTIVE

To determine the operational suitability, through performance tests, collection and analysis of reliability and maintenance data of the CMI radar speedometer on CN locomotives.

2.0 SYSTEM DESCRIPTION

2.1 The radometer is an electronic speedometer specifically designed for use on railroad locomotives. The radometer is completely independent of locomotive wheel and axle assemblies, requires no calibration to compensate for wheel size, and is accurate even during wheel slip condition. An overspeed relay and recorder are provided for driving existing speed indicators and control systems. Radometer comes complete with all the necessary mounting hardware.

2.2 The system consists of the antenna/transceiver unit for mounting under the locomotive frame, a processor/readout module for mounting in the locomotive cab and an interface cable for connecting these modules together.

2.3 The instrument is a doppler radar device similar to the police radar. A low level of microwave beam is directed to the roadbed by the antenna module. A portion of the beam is reflected back into the antenna, its frequency being slightly different or "shifted" from the signal that was sent out if the locomotive is in motion. The amount of the change or shift is directly proportional to the speed of the locomotive. This phenomenon is known as the "Doppler Effect". The frequency change experienced is amplified, processed and translated into miles or kilometres per hour, which is then displayed on the readout module. The entire process is virtually instantaneous.

3.0 SYSTEM INSTALLATION

3.1 The antenna/transceiver is mounted on a fabricated bracket welded underneath the locomotive No.1 end drawbar pocket as shown in Fig.1. The bracket is positioned on the centre line of locomotive in order that the microwave beam strikes the centre of the roadbed. The transceiver opening (white plastic) is always pointed to the opposite or No.2 end of the locomotive. The transceiver mounting bracket is welded to the fabricated bracket. The transceiver is bolted to the mounting bracket and positioned so that the transceiver opening (white plastic) is facing downward at a 45 degree angle. This angle is very critical as every degree of error will induce a 1.2% error in the operation of the unit. This angle can easily be determined using a carpenter's level or an inclinometer available from CMI.

3.2 The cabling between the transceiver unit and display unit is routed to the cab by the most appropriate route. The exposed portion of cable is protected by a flexible conduit supplied with the unit and is shown in Fig.2.

3.3 The Processor/Readout-Display (Speedometer) is central cab located as shown in Fig.3. It consists of the processing unit and four seven-segment LCD (Liquid Crystal Display) numeric display. Below the numeric display is an accelerometer to indicate acceleration or deceleration by means of a series of green LEDS (Light Emitting Diode) extending both right and left of a green centre indicator. Refer to Fig.3.

3.4 Shown in Fig.4 is a CMI Model DT-101 portable testing instrument which is used to verify the accuracy of the Radometer. The DT-101 operates with a 9 volt ALKALINE battery.

Operation:

With the rear mounted sliding panels completely extended, the instrument is placed against the transceiver opening (white plastic), and either hand-held or mechanically secured to transceiver. Set the "Speed Select" switch on the instrument to a desired speed, i.e. 30 M.P.H. (48.2 Km/H). If the Radometer system is accurate, the display unit in the locomotive cab should read 30 M.P.H. (48.2 Km/H). This test can be done to verify the complete speed range of system.

4.0 WORK PERFORMED

4.1 WORK ACCOMPLISHED

4.1.1 Equipment Department Personnel - Headquarters

- W. L. Draper - Assistant Chief - M.P.
- C. R. Battley - Manager, MP Maintenance - M.P.
- R. J. Lusk - System Mechanical Officer - M.P.
- K. H. Kilpatrick - System Electrical Officer - M.P.
- J. R. Lauzon - Technical Officer - Electrical
- L. White - Special Electrical Assistant

Equipment Department Personnel - Regional

Mountain Region

- R. Newbigging - Mechanical Assistant - Region
- K. Ginn - Technical Foreman - Calder Yard

Great Lakes Region

- W. Carswel - Mechanical Assistant - Region
- G. Shepardson - Foreman Electrical - MacMillan Yard

St. Lawrence Region

- Denis Proulx - Mechanical Assistant - Region
- P. Gerber - Search Supervisor - Taschereau Yard

Atlantic Region

- C. DeGier - Sr. Mechanical Assistant - Region

Transportation Department

- R. C. Fields - Manager Developmental Projects - Planning
- L. G. Finnerty - System Master Mechanic - Operations

CN Rail Research

- D. F. Lawless - Sr. Engineering Assistant - Research

4.1.2 Radometer Applications

a) The first installation to a locomotive was made to the Atlantic Region, Gordon Yard, assigned unit 2532 on September 12, 1983.

b) The application of Radometers including unit 2532 as per item (a), is as follows:

1. CN R&D Test Car - R&D facilities, Montreal. Applied April 14, 1983.

2. Gordon Yard - Atlantic Region, Moncton, N.B. Applied to:

   2530 - October 26, 1983
   2531 - November 09, 1983
   2532 - September 15, 1983

3. Taschereau Yard - St. Lawrence Region, Montreal
   Applied to:
   9621 - October 18, 1983
   9622 - September 26, 1983

4. MacMillan Yard - Great Lakes Region, Toronto, Ont.
   Applied to:
   9512 - October 7, 1983
   9514 - October 3, 1983

5. Calder Yard - Mountain Region, Edmonton, Alta.
   Applied to:
   5291 - October 19, 1983
   5292 - October 16, 1983
   5293 - October 27, 1983

c) Initial speedometers received were equipped with 1/2" display characters and were subsequently returned to the supplier for conversion to proper 1" display characters. The receipt of units with 1" display has resulted in the installation activity as outlined in the above.

4.1.3 Performance

Performance tests of the Radometer were conducted on the 7 February 1984 in conjunction with the testing of the Pulse Recorder equipment.

The locomotive road number 9514 equipped with a Radometer was coupled to CN Research Test Car which was also equipped with a Radometer.

The tests performed, covered (a) low speed accuracy; (b) overall speed accuracy; (c) measurement accuracy over standing water (between rails) and (d) measurement accuracy on open trestles. All tests performed satisfactorily. At Cantic, Quebec, the Radometer on Locomotive 9514 at standstill, was found to be fluctuating from 0 to 30 M.P.H. (48.2 Km/H) from no apparent reason. The Radometer was eventually removed and returned to supplier.

4.1.4 Reliability

The evaluaton of Reliability and Maintenance of the Radometer can be summarized as follows:

Unit 5291
- Initial application made October 19, 1983.
- December 2, 1983 - Found plastic lense and enclosure missing.
- December 12, 1983 - Reported "ALL LCD's on display indicating simultaneously". Returned equipment to supplier.
- January 31, 1984 - Reported "Units digit not indicating". Returned equipment to supplier.
- August 10, 1984 - Radometer removed from unit due to numerous complaints received from Engine Crew Master Mechanic that they were unable to read the speed display clearly from both sides of cab.

Unit 5292
- Initial application made October 16, 1983.
- December 2, 1983 - Reported "All segments of LCD display indicating simultaneously". Returned equipment to supplier.
- January 21, 1984 - Reported reading very erratic in relation to actual road speed. Returned equipment to supplier.

Unit 5293
- Initial application made October 27, 1983.
- December 12, 1983 - Reported "All segments of LCD display indicating simultaneously". Returned equipment to supplier.
- June 18, 1984 - Reported "All segments of LCD display indicating simultaneously". Returned equipment to supplier.

Unit 2530
- Initial application made October 26, 1983.
- January 9, 1984 - Reported no speed display. Found B+ wire burnt, indicating a shorted input. Returned equipment to supplier.

Unit 2531
- Initial application made November 9, 1983.
- February 16, 1984 - Reported no back lighting on display. Returned equipment to supplier.

Unit 2532
- Initial application made September 26, 1983.
- September 8, 1984 - Reported "No readout on display". Returned equipment to supplier.

Unit 9622
- Initial applicaton made September 26, 1983.
- January 10, 1984 - Reported "All segments of LCD display indicating simultaneously". On bench test switch had moved to test mode through vibration. Moved test switch to normal position and secured with RTV sealant. Reapplied to locomotive.

Unit 9512 - Initial application made October 7, 1983.
- August 29, 1984 - Reported "No readout on display. Returned equipment to supplier.

Unit 9514 - Initial application made October 3, 1983.
- February 7, 1984 - Reported "Speed readout erratic". Returned equipment to supplier. It is to be noted that 9 out of 11 Radometer applications have experienced one or more road failures with the equipment being returned to supplier, namely Federal Signals Canada Ltd., Willowdale, Ontario.

4.1.5 Problem Areas

1. Since the implementation of the Doppler Radar Locomotive Speedometers in September, 1983, we have noted that the majority of the problems encountered with the system are related to the radometer display unit, i.e. glare reflection from the plastic lense (window) covering the display, dull visual speed display in daylight caused by the lack of contrast between the display background (grey colour) and the display numerals (black colour) and the occasional erratic display read-out at certain locomotive speeds.

2. C.M.I. Incorporated stipulate in their brochure that, should it become necessary to return the Radometer to the factory for service or repairs, both major components, readout and transceiver, were to be returned as a unit.

   This was done with the malfunctioning readouts listed in Item 4.1.4.

   The reliability or accuracy of the antenna/transceiver cannot be ascertained at this time as the supplier did not provide a report to CN Rail detailing the reason(s) for the failures or provide a resolvement on devices returned to the manufacturer.

5.0 TEST RESULTS

5.1 Regarding the CMI Radometer display unit, the comments received from the engine crews have been mostly on the negative side.

The major complaint has been the difficulty experienced in attempting to obtain a clear readout from the seat without having to lean sideways.

Due to its design, the radometer display unit is not suitable for central cab location application, as it provides a dull visual speed display in daylight due to the lack of contrast between the display numerals and display background. Item 4.1.5 details this problem.

The radometers on test are considered as being unreliable, as 90% of the applications have experienced one or more road failaure requiring the removal of radmoeter components and the subsequent return for repairs to supplier, Federal Signals Canada Ltd.

6.0 RECOMMENDATION

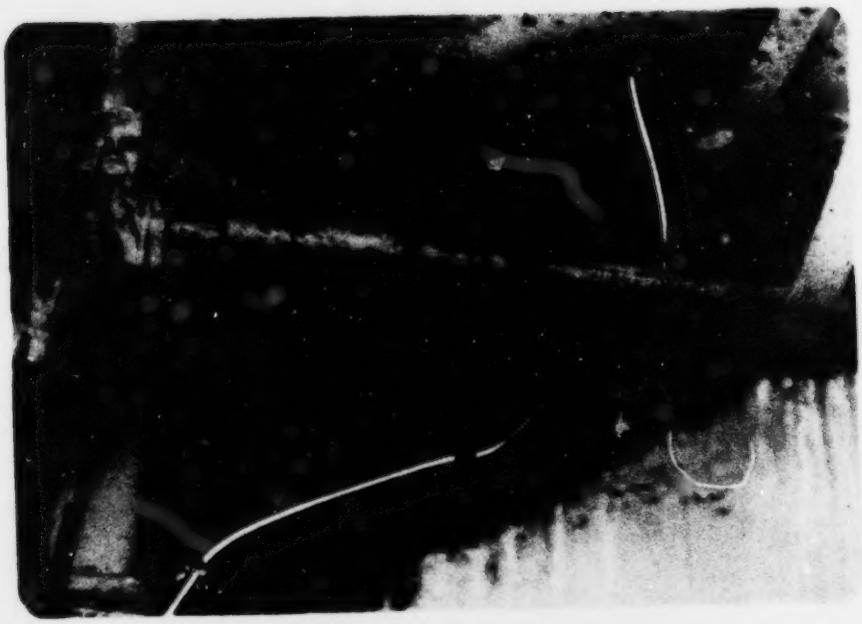
Because of the negative results obtained from the CMI radometer field evaluation to date, we do not see any reason for the pursuing of further testing.

As a note of interest, Canadian National has now adopted as a standard, for replacements and new applications, an Illuminated Arc Type speedometer that provides excellent visibility at all hours of the day, and has proven reliable with respect to accuracy. Furthermore, because of its solid state design, the maintenance cost of speed indicators will be greatly reduced. The response from engine crews has been more than favourable from comments received.

This new style speedometer operated by G.M. Radar System is in service on the 40-SD-50 G.M. Locomotives being delivered to CN this current year.

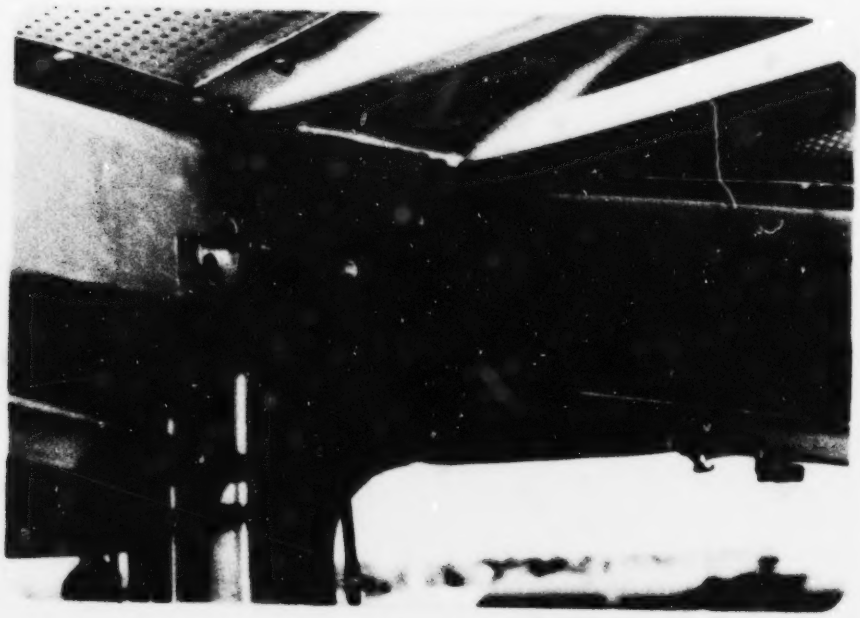
ANTENNA / TRANSCEIVER LOCATION
No. 1 END DRAWBAR POCKET

FIG. 1



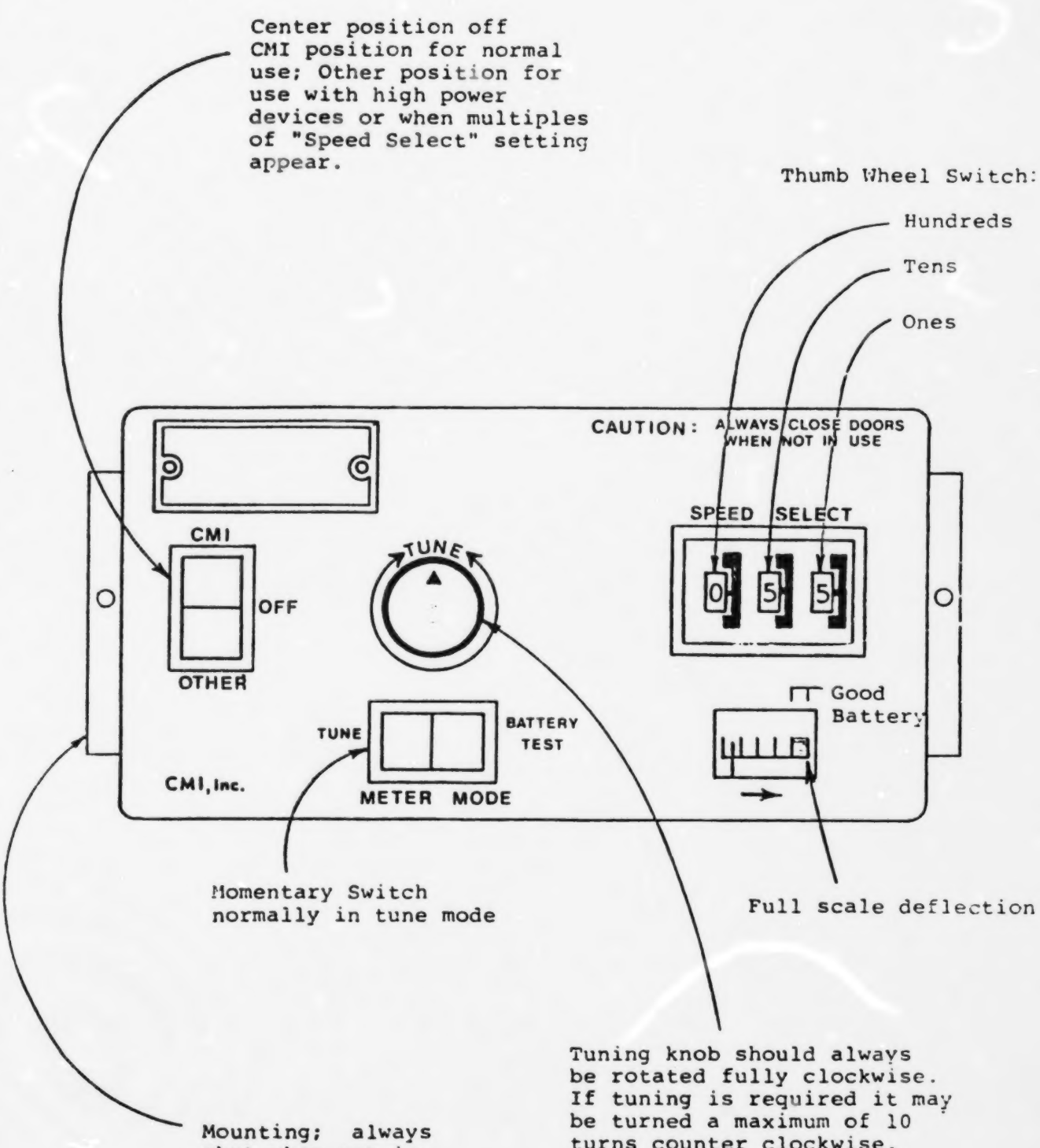
CABLING BETWEEN
TRANSCEIVER AND DISPLAY UNIT IN CAB
LOCOMOTIVE UNDERFRAME

FIG. 2



CENTRAL CAB MOUNT
DISPLAY UNIT

FIG. 3


Center position off CMI position for normal use; Other position for use with high power devices or when multiples of "Speed Select" setting appear.
Thumb Wheel Switch:
Hundreds
Tens
Ones
CAUTION: ALWAYS CLOSE DOORS WHEN NOT IN USE
SPEED SELECT
0
5
5
CMI
OFF
OTHER
TUNE
TUNE
BATTERY TEST
METER MODE
CMI, Inc.
Good Battery
Momentary Switch normally in tune mode
Full scale deflection
Tuning knob should always be rotated fully clockwise. If tuning is required it may be turned a maximum of 10 turns counter clockwise.
Mounting; always shut when not in use to protect Mixer Diode integrity.

CMI MODEL DT-101 VERIFIER

FIG. 4